

n

$$I(J^P) = \frac{1}{2}(\frac{1}{2}^+) \text{ Status: } ***$$

We have omitted some results that have been superseded by later experiments. See our earlier editions.

Anyone interested in the neutron should look at these two new review articles: D. Dubbers and M.G. Schmidt, "The neutron and its role in cosmology and particle physics," *Reviews of Modern Physics* **83** 1111 (2011); and F.E. Wietfeldt and G.L. Greene, "The neutron lifetime," *Reviews of Modern Physics* **83** 1173 (2011).

n MASS (atomic mass units u)

The mass is known much more precisely in u (atomic mass units) than in MeV. See the next data block.

VALUE (u)	DOCUMENT ID	TECN	COMMENT
1.00866491600±0.0000000043	MOHR	12	RVUE 2010 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1.00866491597±0.0000000043	MOHR	08	RVUE 2006 CODATA value
1.00866491560±0.0000000055	MOHR	05	RVUE 2002 CODATA value
1.00866491578±0.0000000055	MOHR	99	RVUE 1998 CODATA value
1.008665904 ± 0.000000014	COHEN	87	RVUE 1986 CODATA value

n MASS (MeV)

The mass is known much more precisely in u (atomic mass units) than in MeV. The conversion from u to MeV, $1 \text{ u} = 931.494\ 061(21) \text{ MeV}/c^2$ (MOHR 12, the 2010 CODATA value), involves the relatively poorly known electronic charge.

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
939.565379±0.000021	MOHR	12	RVUE 2010 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •			
939.565346±0.000023	MOHR	08	RVUE 2006 CODATA value
939.565360±0.000081	MOHR	05	RVUE 2002 CODATA value
939.565331±0.000037	¹ KESSLER	99	SPEC $np \rightarrow d\gamma$
939.565330±0.000038	MOHR	99	RVUE 1998 CODATA value
939.56565 ± 0.00028	^{2,3} DIFILIPPO	94	TRAP Penning trap
939.56563 ± 0.00028	COHEN	87	RVUE 1986 CODATA value
939.56564 ± 0.00028	^{3,4} GREENE	86	SPEC $np \rightarrow d\gamma$
939.5731 ± 0.0027	³ COHEN	73	RVUE 1973 CODATA value

¹ We use the 1998 CODATA u-to-MeV conversion factor (see the heading above) to get this mass in MeV from the much more precisely measured KESSLER 99 value of $1.00866491637 \pm 0.0000000082$ u.

² The mass is known much more precisely in u: $m = 1.0086649235 \pm 0.0000000023$ u. We use the 1986 CODATA conversion factor to get the mass in MeV.

³ These determinations are not independent of the $m_n - m_p$ measurements below.

⁴ The mass is known much more precisely in u: $m = 1.008664919 \pm 0.000000014$ u.

ñ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
939.485±0.051	59	⁵ CRESTI	86	HBC $\bar{p}p \rightarrow \bar{n}n$

⁵ This is a corrected result (see the erratum). The error is statistical. The maximum systematic error is 0.029 MeV.

$$(m_n - m_{\bar{n}})/m_n$$

A test of *CPT* invariance. Calculated from the n and \bar{n} masses, above.

VALUE	DOCUMENT ID
(9±6) × 10⁻⁵	OUR EVALUATION

NODE=S017

NODE=S017

NODE=S017AMU

NODE=S017AMU

NODE=S017AMU

NODE=S017M

NODE=S017M

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NODE=S017M;LINKAGE=C

NODE=S017M;LINKAGE=B

NODE=S017M;LINKAGE=T

NODE=S017M;LINKAGE=Q

NODE=S017M1

NODE=S017M1

NODE=S017M1;LINKAGE=V

NODE=S017DMM

NODE=S017DMM

NODE=S017DMM

m_n – m_p

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1.29333217±0.00000042	6 MOHR	12 RVUE	2010 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1.29333214±0.00000043	7 MOHR	08 RVUE	2006 CODATA value
1.2933317 ± 0.0000005	8 MOHR	05 RVUE	2002 CODATA value
1.2933318 ± 0.0000005	9 MOHR	99 RVUE	1998 CODATA value
1.293318 ± 0.000009	10 COHEN	87 RVUE	1986 CODATA value
1.2933328 ± 0.0000072	GREENE	86 SPEC	$np \rightarrow d\gamma$
1.293429 ± 0.000036	COHEN	73 RVUE	1973 CODATA value
6 The 2010 CODATA mass difference in u is $m_n - m_p = 1.38844919(45) \times 10^{-3}$ u.			
7 Calculated by us from the MOHR 08 ratio $m_n/m_p = 1.00137841918(46)$. In u, $m_n - m_p = 1.38844920(46) \times 10^{-3}$ u.			
8 Calculated by us from the MOHR 05 ratio $m_n/m_p = 1.00137841870 \pm 0.00000000058$. In u, $m_n - m_p = (1.3884487 \pm 0.0000006) \times 10^{-3}$ u.			
9 Calculated by us from the MOHR 99 ratio $m_n/m_p = 1.00137841887 \pm 0.00000000058$. In u, $m_n - m_p = (1.3884489 \pm 0.0000006) \times 10^{-3}$ u.			
10 Calculated by us from the COHEN 87 ratio $m_n/m_p = 1.001378404 \pm 0.000000009$. In u, $m_n - m_p = 0.001388434 \pm 0.000000009$ u.			

n MEAN LIFE

Limits on lifetimes for *bound* neutrons are given in the section "p PARTIAL MEAN LIVES."

The mean life of the neutron, 878.5 ± 0.8 s, obtained by SEREBROV 05 (for a more detailed account, see SEREBROV 08A; and for comments on the systematic error for this result, see STEYERL 10) was so far from our average of seven other measurements, 885.7 ± 0.8 s, that it made no sense to include it in our average. Thus our 2006, 2008, and 2010 *Reviews* stayed with 885.7 ± 0.8 s; but we noted that in light of SEREBROV 05 our value should be regarded as suspect until further experiments clarified matters.

However, after our 2010 *Review*, PICHLMAYER 10 obtained a mean life of 880.7 ± 1.8 s, and we averaged the best seven results to get 881.5 ± 1.5 s for our 2011 off-year web update. Since then, ARZUMANOV 12, responding to comments of SEREBROV 10B, recalculated the systematic corrections to its 2000 measurement (ARZUMANOV 00) and lowered its value from $885.4 \pm 0.9 \pm 0.4$ s to $881.6 \pm 0.8 \pm 1.9$ s. And STEYERL 12 reanalyzed systematic corrections to MAMPE 89 and lowered its value from 887.6 ± 3.0 to $882.5 \pm 1.4 \pm 1.5$ s. Thus the trend is definitely toward a shorter lifetime.

There seems little better to do than to again average the best seven measurements. The result, 880.1 ± 1.1 s (including a scale factor of 1.8), is 5.6 s lower than the value we gave in 2010—a drop of 7.0 old and 5.1 new standard deviations.

For a full review of all matters concerning the neutron lifetime, see F.E. Wietfeldt and G.L. Greene, "The neutron lifetime," *Reviews of Modern Physics* **83** 1173 (2011). In particular, there is a full discussion of the experimental methods and results; and an average lifetime is obtained making several different selections of those results. (The revised ARZUMANOV 12 mean life was not yet available.)

VALUE (s)	DOCUMENT ID	TECN	COMMENT
880.0± 0.9 OUR AVERAGE	Error includes scale factor of 1.4. See the ideogram below. [880.1 ± 1.1 s OUR 2012 AVERAGE Scale factor = 1.8]		
881.6± 0.8± 1.9	11 ARZUMANOV 12	CNTR	UCN double bottle
882.5± 1.4± 1.5	12 STEYERL 12	CNTR	UCN material bottle
880.7± 1.3± 1.2	PICHLMAYER 10	CNTR	UCN material bottle
886.3± 1.2± 3.2	NICO 05	CNTR	In-beam <i>n</i> , trapped <i>p</i>
878.5± 0.7± 0.3	SERE BROV 05	CNTR	UCN gravitational trap
889.2± 3.0± 3.8	BYRNE 96	CNTR	Penning trap
882.6± 2.7	13 MAMPE 93	CNTR	UCN material bottle

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NODE=S017D;LINKAGE=MD

NODE=S017D;LINKAGE=M9

NODE=S017D;LINKAGE=C

NODE=S017T

NODE=S017T

NODE=S017T

NEW

• • • We do not use the following data for averages, fits, limits, etc. • • •

886.8± 1.2± 3.2	DEWEY	03	CNTR	See NICO 05
885.4± 0.9± 0.4	ARZUMANOV	00	CNTR	See ARZUMANOV 12
888.4± 3.1± 1.1	¹⁴ NESVIZHEV...	92	CNTR	UCN material bottle
888.4± 2.9	ALFIMENKOV	90	CNTR	See NESVIZHEVSKII 92
893.6± 3.8± 3.7	BYRNE	90	CNTR	See BYRNE 96
878 ±27 ±14	KOSSAKOW...	89	TPC	Pulsed beam
887.6± 3.0	MAMPE	89	CNTR	See STEYERL 12
877 ±10	PAUL	89	CNTR	Magnetic storage ring
876 ±10 ±19	LAST	88	SPEC	Pulsed beam
891 ± 9	SPIVAK	88	CNTR	Beam
903 ±13	KOSVINTSEV	86	CNTR	UCN material bottle
937 ±18	¹⁵ BYRNE	80	CNTR	
875 ±95	KOSVINTSEV	80	CNTR	
881 ± 8	BONDAREN...	78	CNTR	See SPIVAK 88
918 ±14	CHRISTENSEN	72	CNTR	

11 ARZUMANOV 12 reanalyzes its systematic corrections in ARZUMANOV 00 and obtains this corrected value.

12 STEYERL 12 is a detailed reanalysis of neutron storage loss corrections to the raw data of MAMPE 89, and it replaces that value.

13 IGNATOVICH 95 calls into question some of the corrections and averaging procedures used by MAMPE 93. The response, BONDARENKO 96, denies the validity of the criticisms.

14 The NESVIZHEVSKII 92 measurement has been withdrawn by A. Serebrov.

15 The BYRNE 80 measurement has been withdrawn (J. Byrne, private communication, 1990).

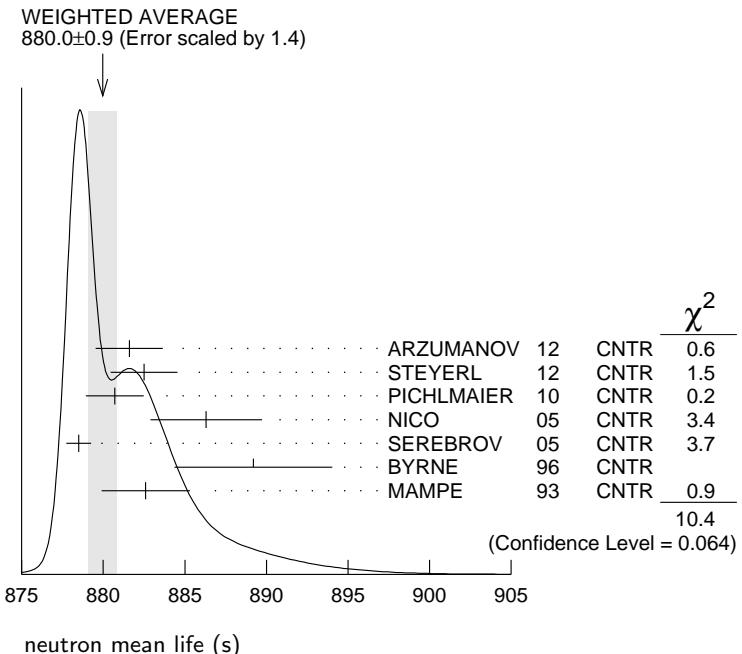
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NODE=S017T;LINKAGE=E

NODE=S017T;LINKAGE=NE

NODE=S017T;LINKAGE=D



n MAGNETIC MOMENT

See the "Note on Baryon Magnetic Moments" in the Λ Listings.

VALUE (μ_N)	DOCUMENT ID	TECN	COMMENT
-1.91304272±0.00000045	MOHR	12	RVUE 2010 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-1.91304273±0.00000045	MOHR	08	RVUE 2006 CODATA value
-1.91304273±0.00000045	MOHR	05	RVUE 2002 CODATA value
-1.91304272±0.00000045	MOHR	99	RVUE 1998 CODATA value
-1.91304275±0.00000045	COHEN	87	RVUE 1986 CODATA value
-1.91304277±0.00000048	¹⁶ GREENE	82	MRS

NODE=S017MM

NODE=S017MM

NODE=S017MM

¹⁶ GREENE 82 measures the moment to be $(1.04187564 \pm 0.00000026) \times 10^{-3}$ Bohr magnetons. The value above is obtained by multiplying this by $m_p/m_e = 1836.152701 \pm 0.000037$ (the 1986 CODATA value from COHEN 87).

n ELECTRIC DIPOLE MOMENT

A nonzero value is forbidden by both T invariance and P invariance. A number of early results have been omitted. See RAMSEY 90, GOLUB 94, and LAMOREAUX 09 for reviews.

VALUE (10^{-25} ecm)	CL%	DOCUMENT ID	TECN	COMMENT
< 0.29	90	17 BAKER	06	MRS UCN's, $h\nu = 2\mu_n B \pm 2d_n E$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 0.63	90	18 HARRIS	99	MRS $d = (-0.1 \pm 0.36) \times 10^{-25}$
< 0.97	90	ALTAREV	96	MRS $(+0.26 \pm 0.40 \pm 0.16) \times 10^{-25}$
< 1.1	95	ALTAREV	92	MRS See ALTAREV 96
< 1.2	95	SMITH	90	MRS See HARRIS 99
< 2.6	95	ALTAREV	86	MRS $d = (-1.4 \pm 0.6) \times 10^{-25}$
0.3 ± 4.8		PENDLEBURY	84	MRS Ultracold neutrons
< 6	90	ALTAREV	81	MRS $d = (2.1 \pm 2.4) \times 10^{-25}$
< 16	90	ALTAREV	79	MRS $d = (4.0 \pm 7.5) \times 10^{-25}$

¹⁷ LAMOREAUX 07 faults BAKER 06 for not including in the estimate of systematic error an effect due to the Earth's rotation. BAKER 07 replies (1) that the effect was included implicitly in the analysis and (2) that further analysis confirms that the BAKER 06 limit is correct as is. See also SILENKO 07.

¹⁸ This HARRIS 99 result includes the result of SMITH 90. However, the averaging of the results of these two experiments has been criticized by LAMOREAUX 00.

n MEAN-SQUARE CHARGE RADIUS

The mean-square charge radius of the neutron, $\langle r_n^2 \rangle$, is related to the neutron-electron scattering length b_{ne} by $\langle r_n^2 \rangle = 3(m_e a_0 / m_n) b_{ne}$, where m_e and m_n are the masses of the electron and neutron, and a_0 is the Bohr radius. Numerically, $\langle r_n^2 \rangle = 86.34 b_{ne}$, if we use a_0 for a nucleus with infinite mass.

VALUE (fm^2)	DOCUMENT ID	COMMENT
-0.1161 ± 0.0022 OUR AVERAGE		Error includes scale factor of 1.3. See the ideogram below.
-0.115 ± 0.002 ± 0.003	KOPECKY 97	<i>ne</i> scattering (Pb)
-0.124 ± 0.003 ± 0.005	KOPECKY 97	<i>ne</i> scattering (Bi)
-0.114 ± 0.003	KOESTER 95	<i>ne</i> scattering (Pb, Bi)
-0.134 ± 0.009	ALEKSANDR... 86	<i>ne</i> scattering (Bi)
-0.115 ± 0.003	19 KROHN 73	<i>ne</i> scattering (Ne, Ar, Kr, Xe)
• • • We do not use the following data for averages, fits, limits, etc. • • •		
-0.117 +0.007 -0.011	BELUSHKIN 07	Dispersion analysis
-0.113 ± 0.003 ± 0.004	KOPECKY 95	<i>ne</i> scattering (Pb)
-0.114 ± 0.003	KOESTER 86	<i>ne</i> scattering (Pb, Bi)
-0.118 ± 0.002	KOESTER 76	<i>ne</i> scattering (Pb)
-0.120 ± 0.002	KOESTER 76	<i>ne</i> scattering (Bi)
-0.116 ± 0.003	KROHN 66	<i>ne</i> scattering (Ne, Ar, Kr, Xe)

¹⁹ This value is as corrected by KOESTER 76.

NODE=S017MM;LINKAGE=A

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NODE=S017EDM

NODE=S017EDM

NODE=S017EDM;LINKAGE=BA

NODE=S017EDM;LINKAGE=B

NODE=S017MCR

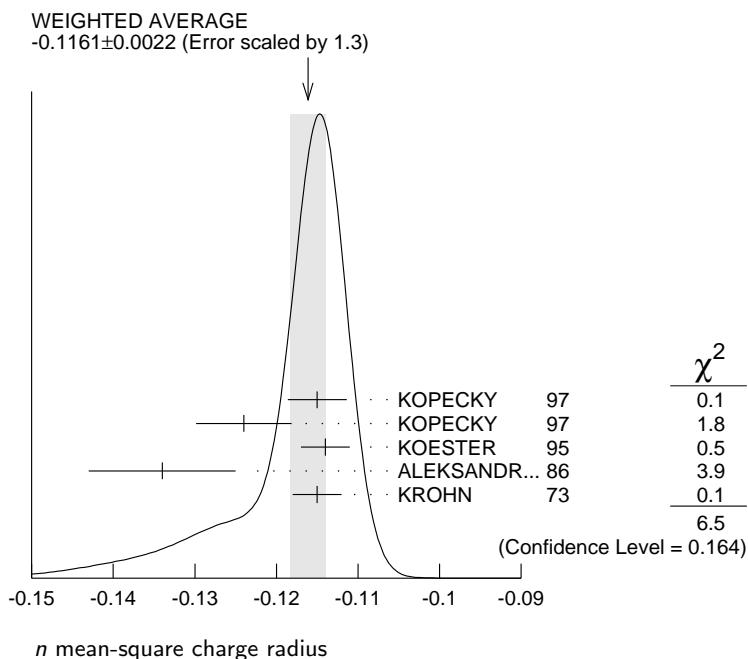
NODE=S017MCR

NODE=S017MCR

OCCUR=2

OCCUR=2

NODE=S017MCR;LINKAGE=A



n MAGNETIC RADIUS

This is the rms magnetic radius, $\sqrt{\langle r_M^2 \rangle}$.

VALUE (fm)	DOCUMENT ID	COMMENT
0.862^{+0.009}_{-0.008}	BELUSHKIN 07	Dispersion analysis

NODE=S017MRD

NODE=S017MRD
NODE=S017MRD

n ELECTRIC POLARIZABILITY α_n

Following is the electric polarizability α_n defined in terms of the induced electric dipole moment by $\mathbf{D} = 4\pi\epsilon_0\alpha_n\mathbf{E}$. For a review, see SCHMIED-MAYER 89.

For a very complete review of the “polarizability of the nucleon and Compton scattering,” see SCHUMACHER 05. His recommended values for the neutron are $\alpha_n = (12.5 \pm 1.7) \times 10^{-4} \text{ fm}^3$ and $\beta_n = (2.7 \pm 1.8) \times 10^{-4} \text{ fm}^3$, which agree with our averages within errors.

VALUE (10^{-4} fm^3)	DOCUMENT ID	TECN	COMMENT
11.6± 1.5 OUR AVERAGE			

NODE=S017EPL

NODE=S017EPL

$12.5 \pm 1.8^{+1.6}_{-1.3}$	20 KOSSELT	03	CNTR $\gamma d \rightarrow \gamma pn$
$8.8 \pm 2.4 \pm 3.0$	21 LUNDIN	03	CNTR $\gamma d \rightarrow \gamma d$
$12.0 \pm 1.5 \pm 2.0$	SCHMIEDM...	91	CNTR n Pb transmission
$10.7^{+3.3}_{-10.7}$	ROSE	90B	CNTR $\gamma d \rightarrow \gamma np$

NODE=S017EPL

• • • We do not use the following data for averages, fits, limits, etc. • • •

13.6	22 KOLB	00	CNTR $\gamma d \rightarrow \gamma np$
0.0 ± 5.0	23 KOESTER	95	CNTR n Pb, n Bi transmission

NODE=S017EPL

$11.7^{+4.3}_{-11.7}$	ROSE	90	CNTR See ROSE 90B
8 ± 10	KOESTER	88	CNTR n Pb, n Bi transmission

NODE=S017EPL

12 ± 10	SCHMIEDM...	88	CNTR n Pb, n C transmission
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NODE=S017EPL

20 KOSSELT 03 gets $\alpha_n - \beta_n = (9.8 \pm 3.6^{+2.1}_{-1.1} \pm 2.2) \times 10^{-4} \text{ fm}^3$, and uses $\alpha_n + \beta_n = (15.2 \pm 0.5) \times 10^{-4} \text{ fm}^3$ from LEVCHUK 00. Thus the errors on α_n and β_n are anti-correlated.

NODE=S017EPL;LINKAGE=KS

21 LUNDIN 03 measures $\alpha_N - \beta_N = (6.4 \pm 2.4) \times 10^{-4} \text{ fm}^3$ and uses accurate values for α_p and β_p and a precise sum-rule result for $\alpha_n + \beta_n$. The second error is a model uncertainty, and errors on α_n and β_n are anticorrelated.

NODE=S017EPL;LINKAGE=LN

22 KOLB 00 obtains this value with a lower limit of $7.6 \times 10^{-4} \text{ fm}^3$ but no upper limit from this experiment alone. Combined with results of ROSE 90, the $1-\sigma$ range is $(7.6-14.0) \times 10^{-4} \text{ fm}^3$.

NODE=S017EPL;LINKAGE=KL

23 KOESTER 95 uses natural Pb and the isotopes 208, 207, and 206. See this paper for a discussion of methods used by various groups to extract α_n from data.

NODE=S017EPL;LINKAGE=A

n MAGNETIC POLARIZABILITY β_n

VALUE (10^{-4} fm 3)	DOCUMENT ID	TECN	COMMENT
3.7±2.0 OUR AVERAGE			
2.7±1.8 $^{+1.3}_{-1.6}$	24 KOSSERT 03	CNTR	$\gamma d \rightarrow \gamma pn$
6.5±2.4±3.0	25 LUNDIN 03	CNTR	$\gamma d \rightarrow \gamma d$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1.6	26 KOLB 00	CNTR	$\gamma d \rightarrow \gamma np$
24 KOSSERT 03 gets $\alpha_n - \beta_n = (9.8 \pm 3.6^{+2.1}_{-1.1} \pm 2.2) \times 10^{-4}$ fm 3 , and uses $\alpha_n + \beta_n = (15.2 \pm 0.5) \times 10^{-4}$ fm 3 from LEVCHUK 00. Thus the errors on α_n and β_n are anti-correlated.			
25 LUNDIN 03 measures $\alpha_N - \beta_N = (6.4 \pm 2.4) \times 10^{-4}$ fm 3 and uses accurate values for α_p and α_p and a precise sum-rule result for $\alpha_n + \beta_n$. The second error is a model uncertainty, and errors on α_n and β_n are anticorrelated.			
26 KOLB 00 obtains this value with an upper limit of 7.6×10^{-4} fm 3 but no lower limit from this experiment alone. Combined with results of ROSE 90, the 1- σ range is $(1.2\text{--}7.6) \times 10^{-4}$ fm 3 .			

n CHARGE

See also " $|q_p + q_e|/e$ " in the proton Listings.

VALUE (10^{-21} e)	DOCUMENT ID	TECN	COMMENT
- 0.2± 0.8 OUR AVERAGE			
- 0.1± 1.1	27 BRESSI 11		Neutrality of SF ₆
- 0.4± 1.1	28 BAUMANN 88		Cold n deflection
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-15 ±22	29 GAEHLER 82	CNTR	Cold n deflection
27 As a limit, this BRESSI 11 value is $< 1 \times 10^{-21}$ e.			
28 The BAUMANN 88 error ±1.1 gives the 68% CL limits about the the value -0.4.			
29 The GAEHLER 82 error ±22 gives the 90% CL limits about the the value -15.			

LIMIT ON $n\bar{n}$ OSCILLATIONS

Mean Time for $n\bar{n}$ Transition in Vacuum

A test of $\Delta B=2$ baryon number nonconservation. MOHAPATRA 80 and MOHAPATRA 89 discuss the theoretical motivations for looking for $n\bar{n}$ oscillations. DOVER 83 and DOVER 85 give phenomenological analyses. The best limits come from looking for the decay of neutrons bound in nuclei. However, these analyses require model-dependent corrections for nuclear effects. See KABIR 83, DOVER 89, ALBERICO 91, and GAL 00 for discussions. Direct searches for $n \rightarrow \bar{n}$ transitions using reactor neutrons are cleaner but give somewhat poorer limits. We include limits for both free and bound neutrons in the Summary Table. See MOHAPATRA 09 for a recent review.

VALUE (s)	CL%	DOCUMENT ID	TECN	COMMENT
$>1.3 \times 10^8$	90	CHUNG 02B	SOU2	n bound in iron
$>8.6 \times 10^7$	90	BALDO...	94	CNTR Reactor (free) neutrons
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$>1 \times 10^7$	90	BALDO...	90	CNTR See BALDO-CEOLIN 94
$>1.2 \times 10^8$	90	BERGER	90	FREJ n bound in iron
$>4.9 \times 10^5$	90	BRESSI	90	CNTR Reactor neutrons
$>4.7 \times 10^5$	90	BRESSI	89	CNTR See BRESSI 90
$>1.2 \times 10^8$	90	TAKITA	86	CNTR n bound in oxygen
$>1 \times 10^6$	90	FIDECARO	85	CNTR Reactor neutrons
$>8.8 \times 10^7$	90	PARK	85B	CNTR
$>3 \times 10^7$		BATTISTONI	84	NUSX
$>2.7 \times 10^7$ – 1.1×10^8		JONES	84	CNTR
$>2 \times 10^7$		CHERRY	83	CNTR

LIMIT ON nn' OSCILLATIONS

Lee and Yang (LEE 56) proposed the existence of mirror world in an attempt to restore global parity symmetry. See BEREZHIANI 06 for a recent discussion.

NODE=S017MPL

NODE=S017MPL

NODE=S017MPL;LINKAGE=KS

NODE=S017MPL;LINKAGE=LN

NODE=S017MPL;LINKAGE=KL

NODE=S017Q

NODE=S017Q

NODE=S017Q

NODE=S017Q;LINKAGE=BR

NODE=S017Q;LINKAGE=B

NODE=S017Q;LINKAGE=A

NODE=S017240

NODE=S017NAN

NODE=S017NAN

NODE=S017NAN;CHECK LIMITS

NODE=S017NOS

NODE=S017NOS

VALUE (s)	CL%	DOCUMENT ID	TECN	COMMENT
>414	90	SEREBROV	08	CNTR UCN, B field on & off
• • • We do not use the following data for averages, fits, limits, etc. • • •				
> 12	95	30 ALTAREV	09A	CNTR UCN, scan $0 \leq B \leq 12.5 \mu\text{T}$
>103	95	BAN	07	CNTR UCN, B field on & off
30 Losses of neutrons due to oscillations to mirror neutrons would be maximal when the magnetic fields B and B' in the two worlds were equal. Hence the scan over B by ALTAREV 09A: the limit applies for any B' over the given range. At $B' = 0$, the limit is 141 s (95% CL).				

n DECAY MODES

Mode	Fraction (Γ_i/Γ)	Confidence level
$\Gamma_1 p e^- \bar{\nu}_e$	100	%
$\Gamma_2 p e^- \bar{\nu}_e \gamma$	[a] $(3.09 \pm 0.32) \times 10^{-3}$	
Γ_3 hydrogen-atom $\bar{\nu}_e$		
Charge conservation (Q) violating mode		
$\Gamma_4 p \nu_e \bar{\nu}_e$	$Q < 8$	$\times 10^{-27}$ 68%

[a] This limit is for γ energies between 15 and 340 keV.

n BRANCHING RATIOS

$\Gamma(p e^- \bar{\nu}_e \gamma)/\Gamma_{\text{total}}$	Γ_2/Γ
VALUE (units 10^{-3})	CL%
3.09 ± 0.11 ± 0.30	31 COOPER
• • • We do not use the following data for averages, fits, limits, etc. • • •	10 CNTR γ, p, e^- coincidence
3.13 ± 0.11 ± 0.33	NICO
<6.9	90 32 BECK
31 This COOPER 10 result is for γ energies between 15 and 340 keV.	06 CNTR γ, p, e^- coincidence
32 This BECK 02 limit is for γ energies between 35 and 100 keV.	02 CNTR γ, p, e^- coincidence

$\Gamma(\text{hydrogen-atom } \bar{\nu}_e)/\Gamma_{\text{total}}$	Γ_3/Γ
VALUE	CL%
<3 × 10 ⁻²	95 33 GREEN
• • • We do not use the following data for averages, fits, limits, etc. • • •	90 RVUE
33 GREEN 90 infers that $\tau(\text{hydrogen-atom } \bar{\nu}_e) > 3 \times 10^4$ s by comparing neutron lifetime measurements made in storage experiments with those made in β -decay experiments. However, the result depends sensitively on the lifetime measurements, and does not of course take into account more recent measurements of same.	

$\Gamma(p \nu_e \bar{\nu}_e)/\Gamma_{\text{total}}$	Γ_4/Γ
Forbidden by charge conservation.	
VALUE	CL%
<8 × 10⁻²⁷	68 34 NORMAN
• • • We do not use the following data for averages, fits, limits, etc. • • •	96 RVUE $^{71}\text{Ga} \rightarrow ^{71}\text{Ge}$ neutrals
<9.7 × 10 ⁻¹⁸	90 ROY
<7.9 × 10 ⁻²¹	VAIDYA
<9 × 10 ⁻²⁴	BARABANOV
<3 × 10 ⁻¹⁹	NORMAN
34 NORMAN 96 gets this limit by attributing SAGE and GALLEX counting rates to the charge-nonconserving transition $^{71}\text{Ga} \rightarrow ^{71}\text{Ge} + \text{neutrals}$ rather than to solar-neutrino reactions.	$^{113}\text{Cd} \rightarrow ^{113m}\text{In}$ neutrals.

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NODE=S017NOS

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NODE=S017245;NODE=S017

DESIG=1;OUR EVAL;→ UNCHECKED ←
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DESIG=3

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NODE=S017R2
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NODE=S017254

$n \rightarrow pe^- \bar{\nu}_e$ DECAY PARAMETERS

See the above "Note on Baryon Decay Parameters." For discussions of recent results, see the references cited at the beginning of the section on the neutron mean life. For discussions of the values of the weak coupling constants g_A and g_V obtained using the neutron lifetime and asymmetry parameter A , comparisons with other methods of obtaining these constants, and implications for particle physics and for astrophysics, see DUBBERS 91 and WOOLCOCK 91. For tests of the $V-A$ theory of neutron decay, see EROZOLIMSKII 91B, MOSTOVOI 96, NICO 05, SEVERIJNS 06, and ABELE 08.

$\lambda \equiv g_A / g_V$

VALUE DOCUMENT ID TECN COMMENT
-1.2701 ± 0.0025 OUR AVERAGE Error includes scale factor of 1.9. See the ideogram below.

-1.27590 ± 0.00239	+0.00331 -0.00377	35 PLASTER	12 UCNA	Ultracold n , polarized	■
-1.2739	± 0.0019	36 ABELE	02 SPEC	Cold n , polarized, A	
-1.2686	± 0.0046	37 MOSTOVOI	01 CNTR	A and $B \times$ polarizations	
-1.266	± 0.004	LIAUD	97 TPC	Cold n , polarized, A	
-1.2594	± 0.0038	38 YEROZLIM...	97 CNTR	Cold n , polarized, A	
-1.262	± 0.005	BOPP	86 SPEC	Cold n , polarized, A	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
-1.27590	+0.00409 -0.00445	LIU	10 UCNA	See PLASTER 12	
-1.275	± 0.006	± 0.015	08 SCHUMANN	CNTR	Cold n , polarized
-1.274	± 0.003	ABELE	97D SPEC	Cold n , polarized, A	
-1.266	± 0.004	SCHRECK...	95 TPC	See LIAUD 97	
-1.2544	± 0.0036	ERÖZOLIM...	91 CNTR	See YEROZOLIM-SKY 97	
-1.226	± 0.042	MOSTOVY	83 RVUE		
-1.261	± 0.012	ERÖZOLIM...	79 CNTR	Cold n , polarized, A	
-1.259	± 0.017	39 STRATOWA	78 CNTR	p recoil spectrum, a	
-1.263	± 0.015	ERÖZOLIM...	77 CNTR	See EROZOLIMSKII 79	
-1.250	± 0.036	39 DOBROZE...	75 CNTR	See STRATOWA 78	
-1.258	± 0.015	40 KROHN	75 CNTR	Cold n , polarized, A	
-1.263	± 0.016	41 KROPF	74 RVUE	n decay alone	
-1.250	± 0.009	41 KROPF	74 RVUE	n decay + nuclear ft	

35 This PLASTER 12 value is identical with that given in LIU 10, but the experiment is now described in detail.

36 This is the combined result of ABELE 02 and ABELE 97D.

37 MOSTOVOI 01 measures the two P -odd correlations A and B , or rather SA and SB , where S is the n polarization, in free neutron decay.

38 YEROZOLIMSKY 97 makes a correction to the EROZOLIMSKII 91 value.

39 These experiments measure the absolute value of g_A/g_V only.

40 KROHN 75 includes events of CHRISTENSEN 70.

41 KROPF 74 reviews all data through 1972.

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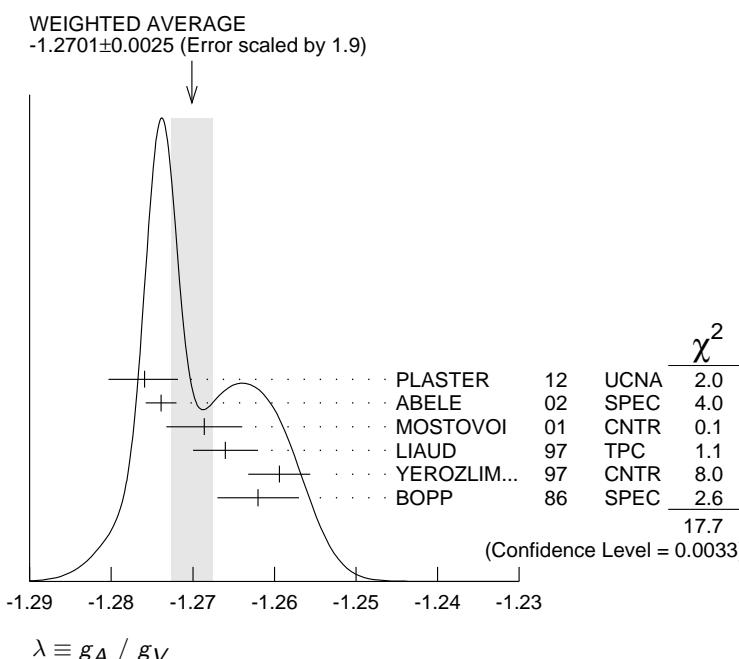
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NODE=S017AV;LINKAGE=YZ

NODE=S017AV;LINKAGE=E

NODE=S017AV;LINKAGE=K

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e^- ASYMMETRY PARAMETER A

This is the neutron-spin electron-momentum correlation coefficient. Unless otherwise noted, the values are corrected for radiative effects and weak magnetism. In the Standard Model, A is related to $\lambda \equiv g_A/g_V$ by $A = -2\lambda(\lambda + 1) / (1 + 3\lambda^2)$; this assumes that g_A and g_V are real.

VALUE	DOCUMENT ID	TECN	COMMENT
-0.1176 ± 0.0011 OUR AVERAGE			Error includes scale factor of 2.1. See the ideogram below.

-0.11966 ± 0.00089	+0.00123 -0.00140	42 PLASTER	12 UCNA	Ultracold n , polarized
-0.1189	± 0.0007	43 ABELE	02 SPEC	Cold n , polarized
-0.1160	± 0.0009	LIAUD	97 TPC	Cold n , polarized
-0.1135	± 0.0014	44 YEROZLIM...	97 CNTR	Cold n , polarized
-0.1146	± 0.0019	BOPP	86 SPEC	Cold n , polarized

• • • We do not use the following data for averages, fits, limits, etc. • • •

-0.11966 ± 0.00089	+0.00123 -0.00140	LIU	10 UCNA	See PLASTER 12
-0.1138	± 0.0046	PATTIE	09 SPEC	Ultracold n , polarized
-0.1168	± 0.0017	45 MOSTOVOI	01 CNTR	Inferred
-0.1189	± 0.0012	ABELE	97D SPEC	Cold n , polarized
-0.1160	± 0.0009	SCHRECK...	95 TPC	See LIAUD 97
-0.1116	± 0.0014	EROZOLIM...	91 CNTR	See YEROZOLIM-SKY 97
-0.114	± 0.005	46 EROZOLIM...	79 CNTR	Cold n , polarized
-0.113	± 0.006	46 KROHN	75 CNTR	Cold n , polarized

42 This PLASTER 12 value is identical with that given in LIU 10, but the experiment is now described in detail.

43 This is the combined result of ABELE 02 and ABELE 97D.

44 YEROZOLIMSKY 97 makes a correction to the EROZOLIMSKII 91 value.

45 MOSTOVOI 01 calculates this from its measurement of $\lambda = g_A/g_V$ above.

46 These results are not corrected for radiative effects and weak magnetism, but the corrections are small compared to the errors.

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NODE=S017BA

NODE=S017BA

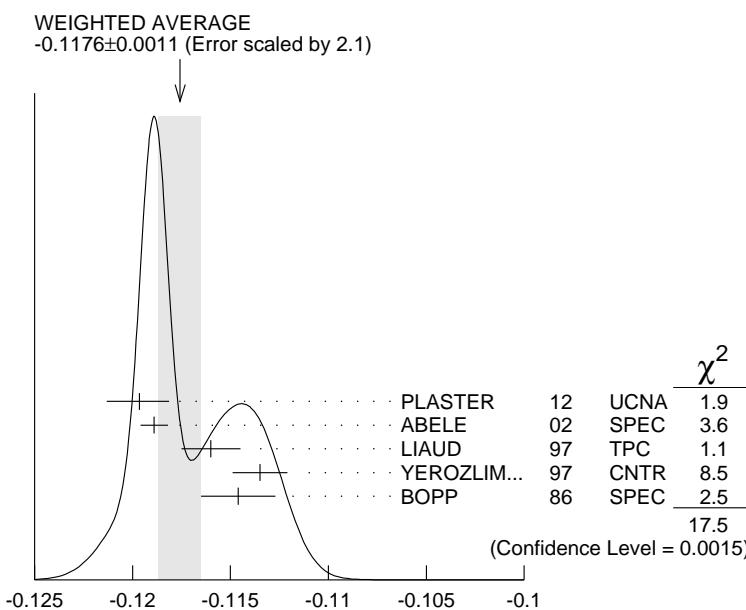
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NODE=S017BA;LINKAGE=VB

NODE=S017BA;LINKAGE=YZ

NODE=S017BA;LINKAGE=MV

NODE=S017BA;LINKAGE=A



e^- asymmetry parameter A

$\bar{\nu}_e$ ASYMMETRY PARAMETER B

This is the neutron-spin antineutrino-momentum correlation coefficient. In the Standard Model, B is related to $\lambda \equiv g_A/g_V$ by $B = 2\lambda(\lambda - 1) / (1 + 3\lambda^2)$; this assumes that g_A and g_V are real.

VALUE	DOCUMENT ID	TECN	COMMENT
0.9807 ± 0.0030 OUR AVERAGE			

0.9802 ± 0.0034 ± 0.0036	SCHUMANN 07	CNTR	Cold n , polarized
0.967 ± 0.006 ± 0.010	KREUZ 05	CNTR	Cold n , polarized
0.9801 ± 0.0046	SERE BROV 98	CNTR	Cold n , polarized
0.9894 ± 0.0083	KUZNETSOV 95	CNTR	Cold n , polarized
1.00 ± 0.05	CHRISTENSEN 70	CNTR	Cold n , polarized
0.995 ± 0.034	EROZOLIM... 70C	CNTR	Cold n , polarized

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.9876 ± 0.0004	47 MOSTOVOI 01	CNTR	Inferred
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NODE=S017NA

NODE=S017NA

NODE=S017NA

47 MOSTOVOI 01 calculates this from its measurement of $\lambda = g_A/g_V$ above.

PROTON ASYMMETRY PARAMETER C

Describes the correlation between the neutron spin and the proton momentum. In the Standard Model, C is related to $\lambda \equiv g_A/g_V$ by $C = -x_c(A + B) = x_c 4\lambda/(1 + 3\lambda^2)$, where $x_c = 0.27484$ is a kinematic factor; this assumes that g_A and g_V are real.

VALUE	DOCUMENT ID	TECN	COMMENT
-0.2377 ± 0.0010 ± 0.0024	SCHUMANN 08	CNTR	Cold n, polarized

e- $\bar{\nu}_e$ ANGULAR CORRELATION COEFFICIENT a

For a review of past experiments and plans for future measurements of the a parameter, see WIETFELDT 05. In the Standard Model, a is related to $\lambda \equiv g_A/g_V$ by $a = (1 - \lambda^2) / (1 + 3\lambda^2)$; this assumes that g_A and g_V are real.

VALUE	DOCUMENT ID	TECN	COMMENT
-0.103 ± 0.004 OUR AVERAGE			
-0.1054 ± 0.0055	BYRNE 02	SPEC	Proton recoil spectrum
-0.1017 ± 0.0051	STRATOWA 78	CNTR	Proton recoil spectrum
-0.091 ± 0.039	GRIGOREV 68	SPEC	Proton recoil spectrum
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-0.1045 ± 0.0014	48 MOSTOVOI 01	CNTR	Inferred
48 MOSTOVOI 01 calculates this from its measurement of $\lambda = g_A/g_V$ above.			

ϕ_{AV} , PHASE OF g_A RELATIVE TO g_V

Time reversal invariance requires this to be 0 or 180°. This is related to D given in the next data block and $\lambda \equiv g_A/g_V$ by $\sin(\phi_{AV}) \equiv D(1+3\lambda^2)/2|\lambda|$; this assumes that g_A and g_V are real.

VALUE (°)	CL%	DOCUMENT ID	TECN	COMMENT
180.017 ± 0.026 OUR AVERAGE				
[(180.018 ± 0.026)° OUR 2012 AVERAGE]				
180.012 ± 0.028	68	CHUPP 12	CNTR	Cold n, polarized > 91%
180.04 ± 0.09		SOLDNER 04	CNTR	Cold n, polarized
180.08 ± 0.13		LISING 00	CNTR	Polarized > 93%
• • • We do not use the following data for averages, fits, limits, etc. • • •				
180.013 ± 0.028		MUMM 11	CNTR	See CHUPP 12
179.71 ± 0.39		EROZOLIM... 78	CNTR	Cold n, polarized
180.35 ± 0.43		EROZOLIM... 74	CNTR	Cold n, polarized
181.1 ± 1.3	49	KROPF 74	RVUE	n decay
180.14 ± 0.22		STEINBERG 74	CNTR	Cold n, polarized

49 KROPF 74 reviews all data through 1972.

TRIPLE CORRELATION COEFFICIENT D

These are measurements of the component of n spin perpendicular to the decay plane in β decay. Should be zero if T invariance is not violated.

VALUE (units 10^{-4})	DOCUMENT ID	TECN	COMMENT
-1.2 ± 2.0 OUR AVERAGE			
- 0.94 ± 1.89 ± 0.97	CHUPP 12	CNTR	Cold n, polarized > 91%
- 2.8 ± 6.4 ± 3.0	SOLDNER 04	CNTR	Cold n, polarized
- 6 ± 12 ± 5	LISING 00	CNTR	Polarized > 93%
• • • We do not use the following data for averages, fits, limits, etc. • • •			
- 0.96 ± 1.89 ± 1.01	MUMM 11	CNTR	See CHUPP 12
+22 ± 30	EROZOLIM... 78	CNTR	Cold n, polarized
-27 ± 50	50 EROZOLIM... 74	CNTR	Cold n, polarized
-11 ± 17	STEINBERG 74	CNTR	Cold n, polarized

50 EROZOLIMSKII 78 says asymmetric proton losses and nonuniform beam polarization may give a systematic error up to 30×10^{-4} , thus increasing the EROZOLIMSKII 74 error to 50×10^{-4} . STEINBERG 74 and STEINBERG 76 estimate these systematic errors to be insignificant in their experiment.

TRIPLE CORRELATION COEFFICIENT R

Another test of time-reversal invariance. R measures the polarization of the electron in the direction perpendicular to the plane defined by the neutron spin and the electron momentum. $R = 0$ for T invariance.

VALUE	DOCUMENT ID	TECN	COMMENT
0.004 ± 0.013 OUR AVERAGE	[0.008 ± 0.016 OUR 2012 AVERAGE]		
+0.004 ± 0.012 ± 0.005	51 KOZELA 12	CNTR	Mott polarimeter
• • • We do not use the following data for averages, fits, limits, etc. • • •			
+0.008 ± 0.015 ± 0.005	KOZELA 09	CNTR	See KOZELA 12

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NODE=S017APC

NODE=S017APC

NODE=S017BNC

NODE=S017BNC

NODE=S017BNC

NODE=S017BNC;LINKAGE=MV

NODE=S017F

NODE=S017F

NODE=S017F

NEW

NODE=S017F;LINKAGE=Q

NODE=S017D1

NODE=S017D1

NODE=S017D1

NODE=S017D1;LINKAGE=E

NODE=S017TCC

NODE=S017TCC

NODE=S017TCC

NEW

51 KOZELA 12 also measures the polarization of the electron along the direction of the neutron spin. This is nonzero in the Standard Model; the correlation coefficient is $N = +0.067 \pm 0.011 \pm 0.004$.

NODE=S017TCC;LINKAGE=KO

REFERENCES

We have omitted some papers that have been superseded by later experiments. See our earlier editions.

ARZUMANOV	12	JETPL 95 224 Translated from ZETFP 95 248.	S.S. Arzumanov <i>et al.</i>	(KIAE)	REFID=54075
CHUPP	12	PR C86 035505	T.E. Chupp <i>et al.</i>	(MICH, UCB, WASH+)	REFID=54626
KOZELA	12	PR C85 045501	A. Kozela <i>et al.</i>	(nTRV Collab.)	REFID=54330
MOHR	12	RMP 84 1527	P.J. Mohr, B.N. Taylor, D.B. Newell	(NIST)	REFID=53956
PLASTER	12	PR C86 055501	B. Plaster <i>et al.</i>	(UCNA Collab.)	REFID=54674
STEYERL	12	PR C85 065503	A. Steyerl <i>et al.</i>	(URI, SUSS)	REFID=54484
BRESSI	11	PR A83 052101	G. Bressi <i>et al.</i>	(LEGN, PAVII, PADO, TRST+)	REFID=53785
DUBBERS	11	RMP 83 1111	D. Dubbers, M.G. Schmidt	(HEID)	REFID=53871
MUMM	11	PRL 107 102301	H.P. Mumm <i>et al.</i>	(NIST, WASH, MICH, LBL+)	REFID=53756
WIETFELDT	11	RMP 83 1173	F.E. Wietfeldt, G.L. Greene	(TULA, TENN)	REFID=53884
COOPER	10	PR C81 035503	R.L. Cooper <i>et al.</i>	(MICH, NIST, TULA+)	REFID=53290
LIU	10	PRL 105 181803	J. Liu <i>et al.</i>	(UCNA Collab.)	REFID=53460
Also		PRL 105 219903 (errat)	J. Liu <i>et al.</i>	(UCNA Collab.)	REFID=53461
PICHLMAIER	10	PL B693 221	A. Pichlmaier <i>et al.</i>	(MUNT, PNPI, ILLG)	REFID=53426
SERE BROV	10B	PR C82 035501	A.P. Serebrov, A.K. Fomin	(PNPI)	REFID=53521
Also		JETPL 92 271	A.P. Serebrov, A.K. Fomin	(PNPI)	REFID=53474
STEYERL	10	PR C81 055505	A. Steyerl <i>et al.</i>	(URI)	REFID=54999
ALTAREV	09A	PR D80 032003	I. Altarev <i>et al.</i>	(MUNT, RAL, CAEN+)	REFID=52962
KOZELA	09	PRL 102 172301	A. Kozela <i>et al.</i>	(JAGL, CRAC, PSI, CAEN+)	REFID=52878
LAMOREAUX	09	JPG 36 104002	S.K. Lamoreaux, R. Golub	(YALE, NCSU)	REFID=53047
MOHAPATRA	09	JPG 36 104006	R.N. Mohapatra	(UMD)	REFID=53051
PATTIE	09	PRL 102 012301	R.W. Pattie Jr. <i>et al.</i>	(Los Alamos UCNA Collab.)	REFID=52614
ABELE	08	PPNP 60 1	H. Abele	(HEID)	REFID=53234
MOHR	08	RMP 80 633	P.J. Mohr, B.N. Taylor, D.B. Newell	(NIST)	REFID=52197
SCHUMANN	08	PRL 100 151801	M. Schumann <i>et al.</i>	(HEID, ILLG, KARL+)	REFID=52190
SERE BROV	08	PL B663 181	A.P. Serebrov <i>et al.</i>	(PNPI, IOFF, ILLG+)	REFID=52457
SERE BROV	08A	PR C78 035505	A.P. Serebrov <i>et al.</i>	(PNPI, JINR, ILLG)	REFID=52521
BAKER	07	PRL 98 149102	C.A. Baker <i>et al.</i>	(RAL, SUSS, ILLG)	REFID=51751
BAN	07	PRL 99 161603	G. Ban <i>et al.</i>	(CAEN, JAGL, PSI, JINR+)	REFID=52010
BELUSHKIN	07	PR C75 035202	M.A. Belushkin, H.W. Hammer, U.-G. Meissner (BONN+)	REFID=53687	
LAMOREAUX	07	PRL 98 149101	S.K. Lamoreaux, R. Golub	(YALE, NCSU)	REFID=51750
SCHUMANN	07	PRL 99 191803	M. Schumann <i>et al.</i>	(HEID, ILLG, KARL+)	REFID=52019
SILENKO	07	PPNL 4 468	A.Y. Silenko	(Belarussian U.)	REFID=52108
Also		Translated from PFECLAY 6 784.			
BAKER	06	PRL 97 131801	C.A. Baker <i>et al.</i>	(RAL, SUSS, ILLG)	REFID=51418
BEREZHIANI	06	PRL 96 081801	Z. Berezhiani, L. Bento	(Aquila U., LISB)	REFID=52192
NICO	06	NAT 444 1059	J.S. Nico <i>et al.</i>	(NIST, TULN, MICH, UMD+)	REFID=52083
SEVERIJNS	06	RMP 78 991	N. Severijns, M. Beck, O. Naviliat-Cuncic	(LEUV+)	REFID=51580
KREUZ	05	PL B619 263	M. Kreuz <i>et al.</i>	(HEID, ILLG, MANZ, KARL+)	REFID=50655
MOHR	05	RMP 77 1	P.J. Mohr, B.N. Taylor	(NIST)	REFID=49695
NICO	05	PR C71 055502	J.S. Nico <i>et al.</i>	(NIST, TULN, IND, TENN+)	REFID=50671
SCHUMACHER	05	PPNP 55 567	M. Schumacher	(GOET)	REFID=51658
SERE BROV	05	PL B605 72	A. Serebrov <i>et al.</i>	(PNPI, JINR, ILLG)	REFID=50382
Also		SPU 48 867	A.P. Serebrov <i>et al.</i>	(PPNI, JINR, ILLG)	REFID=51385
Translated from UFN 175 905.					
WIETFELDT	05	MPL A20 1783	F.E. Wietfeldt	(TULN)	REFID=50974
SOLDNER	04	PL B581 49	T. Soldner <i>et al.</i>	(ILLG, MUNT)	REFID=49817
DEWEY	03	PRL 91 152302	M.S. Dewey <i>et al.</i>	(NIST, TULN, IND+)	REFID=49656
KOSSERT	03	EPJ A16 259	K. Kosser <i>et al.</i>	(Mainz MAMI Collab.)	REFID=49288
Also		PRL 88 162301	K. Kosser <i>et al.</i>	(Mainz MAMI Collab.)	REFID=48922
LUNDIN	03	PRL 90 192501	M. Lundin <i>et al.</i>		REFID=49388
ABELE	02	PRL 88 211801	H. Abele <i>et al.</i>	(PERKEO-II Collab.)	REFID=48707
BECK	02	JETPL 76 332	M. Beck <i>et al.</i>	(LEUV, SUSS, KIAE, PNPI)	REFID=49035
Translated from ZETFP 76 392.					
BYRNE	02	JPG 28 1325	J. Byrne <i>et al.</i>		REFID=48711
CHUNG	02B	PR D66 032004	J. Chung <i>et al.</i>	(SOUDAN-2 Collab.)	REFID=48903
MOSTOVOI	01	PAN 64 1955	Yu.A. Mostovoi <i>et al.</i>		REFID=48470
Translated from YAF 64 2040.					
ARZUMANOV	00	PL B483 15	S. Arzumanov <i>et al.</i>		REFID=47653
GAL	00	PR C61 028201	A. Gal		REFID=47571
KOLB	00	PRL 85 1388	N.R. Kolb <i>et al.</i>		REFID=47741
LAMOREAUX	00	PR D61 051301	S.K. Lamoreaux, R. Golub		REFID=47503
LEVCHUK	00	NP A674 449	M.I. Levchuk, A.I. L'vov	(BELA, LEBD)	REFID=50532
LISING	00	PR C62 055501	L.J. Lising <i>et al.</i>	(NIST emiT Collab.)	REFID=47812
HARRIS	99	PRL 82 904	P.G. Harris <i>et al.</i>		REFID=46737
KESSLER	99	PL A255 221	E.G. Kessler Jr <i>et al.</i>		REFID=47182
MOHR	99	JPCRD 28 1713	P.J. Mohr, B.N. Taylor	(NIST)	REFID=47256
Also		RMP 72 351	P.J. Mohr, B.N. Taylor	(NIST)	REFID=47373
SERE BROV	98	JETPL 86 1074	A.P. Serebrov <i>et al.</i>		REFID=46038
Translated from ZETFP 113 1963.					
ABELE	97D	PL B407 212	H. Abele <i>et al.</i>	(HEIDP, ILLG)	REFID=45627
KOPECKY	97	PR C56 2229	S. Kopecky <i>et al.</i>		REFID=48491
LIAUD	97	NP A612 53	P. Liaud <i>et al.</i>	(ILLG, LAPP)	REFID=45335
YEROZLIM...	97	PL B412 240	B.G. Erozolimsky <i>et al.</i>	(HARV, PNPI, KIAE)	REFID=45826
ALTAREV	96	PAN 59 1152	I.S. Altarev <i>et al.</i>	(PNPI)	REFID=44778
Translated from YAF 59 1204.					
BONDAREN...	96	JETPL 64 416	L.N. Bondarenko <i>et al.</i>	(KIAE)	REFID=44943
Translated from ZETFP 64 382.					
BYRNE	96	EPL 33 187	J. Byrne <i>et al.</i>	(SUSS, ILLG)	REFID=44766
MOSTOVOI	96	PAN 59 968	Y.A. Mostovoy	(KIAE)	REFID=44777
Translated from YAF 59 1013.					
NORMAN	96	PR D53 4086	E.B. Norman, J.N. Bahcall, M. Goldhaber	(LBL+)	REFID=44783
IGNATOVICH	95	JETPL 62 1	V.K. Ignatovich	(JINR)	REFID=44448
Translated from ZETFP 62 3.					

KOESTER	95	PR C51 3363	L. Koester <i>et al.</i>	(+)	REFID=44275
KOPECKY	95	PRL 74 2427	R. Kopecky <i>et al.</i>	(PNPI, KIAE, HARV+)	REFID=48492
KUZNETSOV	95	PRL 75 794	I.A. Kuznetsov <i>et al.</i>	(MUNT, ILLG, LAPP)	REFID=44348
SCHRECK...	95	PL B349 427	K. Schreckenbach <i>et al.</i>	(HEID, ILLG, PADO+)	REFID=44266
BALDO...	94	ZPHY C63 409	M. Baldo-Ceolin <i>et al.</i>	(MIT)	REFID=43097
DIFILIPPO	94	PRL 73 1481	F. DiFilippo <i>et al.</i>	(MIT)	REFID=43992
Also		PRL 71 1998	V. Natarajan <i>et al.</i>	(MIT)	REFID=43510
GOLUB	94	PRPL 237C 1	R. Golub, K. Lamoreaux	(HAHN, WASH)	REFID=44002
MAMPE	93	JETPL 57 82	B. Mampe <i>et al.</i>	(KIAE)	REFID=43324
		Translated from ZETFP 57 77.			
ALTAREV	92	PL B276 242	I.S. Altarev <i>et al.</i>	(PNPI)	REFID=41980
NESVIZHEV...	92	JETP 75 405	V.V. Nesvizhevsky <i>et al.</i>	(PNPI, JINR)	REFID=42187
		Translated from ZETF 102 740.			
ALBERICO	91	NP A523 488	W.M. Alberico, A. de Pace, M. Pignone	(TORI)	REFID=41492
DUBBERS	91	NP A527 239c	D. Dubbers	(ILLG)	REFID=41565
Also		EPL 11 195	D. Dubbers, W. Mampe, J. Dohner	(ILLG, HEID)	REFID=41232
EROZOLIM...	91	PL B263 33	B.G. Erozolimsky <i>et al.</i>	(PNPI, KIAE)	REFID=41538
Also		SJNP 52 999	B.G. Erozolimsky <i>et al.</i>	(PNPI, KIAE)	REFID=41490
		Translated from YAF 52 1583.			
EROZOLIM...	91B	SJNP 53 260	B.G. Erozolimsky, Y.A. Mostovoy	(KIAE)	REFID=41564
		Translated from YAF 53 418.			
SCHMIEDM...	91	PRC 66 1015	J. Schmiedmayer <i>et al.</i>	(TUW, ORNL)	REFID=41471
WOOLCOCK	91	MPL A6 2579	W.S. Woolcock	(CANB)	REFID=41594
ALFIMENKOV	90	JETPL 52 373	V.P. Alfimenkov <i>et al.</i>	(PNPI, JINR)	REFID=41473
		Translated from ZETFP 52 984.			
BALDO...	90	PL B236 95	M. Baldo-Ceolin <i>et al.</i>	(PADO, PAVI, HEIDP+)	REFID=41200
BERGER	90	PL B240 237	C. Berger <i>et al.</i>	(FREIUS Collab.)	REFID=41210
BRESSI	90	NC 103A 731	G. Bressi <i>et al.</i>	(PAVI, ROMA, MILA)	REFID=41308
BYRNE	90	PRC 65 289	J. Byrne <i>et al.</i>	(SUSS, NBS, SCOT, CBNM)	REFID=41191
GREEN	90	JPG 16 L75	K. Green, D. Thompson	(RAL)	REFID=41280
RAMSEY	90	ARNPS 40 1	N.F. Ramsey	(HARV)	REFID=41615
ROSE	90	PL B234 460	K.W. Rose <i>et al.</i>	(GOET, MPCM, MANZ)	REFID=41101
ROSE	90B	NP A514 621	K.W. Rose <i>et al.</i>	(GOET, MPCM)	REFID=41290
SMITH	90	PL B234 191	K.F. Smith <i>et al.</i>	(SUSS, RAL, HARV+)	REFID=41103
BRESSI	89	ZPHY C45 175	G. Bressi <i>et al.</i>	(INFN, MILA, PAVI, ROMA)	REFID=40856
DOVER	89	NIM A284 13	C.B. Dover, A. Gal, J.M. Richard	(BNL, HEBR+)	REFID=41125
KOSSAKOW...	89	NP A503 473	R. Kossakowski <i>et al.</i>	(LAPP, SAVO, ISNG+)	REFID=41043
MAMPE	89	PRC 63 593	W. Mampe <i>et al.</i>	(ILLG, RISL, SUSS, UR)	REFID=40746
MOHAPATRA	89	NIM A284 1	R.N. Mohapatra	(UMD)	REFID=41124
PAUL	89	ZPHY C45 25	W. Paul <i>et al.</i>	(BONN, WUPP, MPIH, ILLG)	REFID=41042
SCHMIEDM...	89	NIM A284 137	J. Schmiedmayer, H. Rauch, P. Riehs	(WIEN)	REFID=41045
BAUMANN	88	PR D37 3107	J. Baumann <i>et al.</i>	(BAYR, MUNI, ILLG)	REFID=40592
KOESTER	88	ZPHY A329 229	L. Koester, W. Waschkowski, J. Meier	(MUNI, MUNT)	REFID=41026
LAST	88	PRC 60 995	I. Last <i>et al.</i>	(HEIDP, ILLG, ANL)	REFID=40411
SCHMIEDM...	88	PRC 61 1065	J. Schmiedmayer, H. Rauch, P. Riehs	(TUV)	REFID=40616
Also		PRL 61 2509 (erratum)	J. Schmiedmayer, H. Rauch, P. Riehs	(TUV)	REFID=40945
SPIVAK	88	JETPL 67 1735	P.E. Spivak	(KIAE)	REFID=40777
		Translated from ZETF 94 1.			
COHEN	87	RMP 59 1121	E.R. Cohen, B.N. Taylor	(RISC, NBS)	REFID=11616
ALEKSANDR...	86	SJNP 44 900	Yu.A. Aleksandrov <i>et al.</i>		REFID=48497
		Translated from YAF 44 1384.			
ALTAREV	86	JETPL 44 460	I.S. Altarev <i>et al.</i>	(PNPI)	REFID=40279
		Translated from ZETFP 44 360.			
BOPP	86	PRL 56 919	P. Bopp <i>et al.</i>	(HEIDP, ANL, ILLG)	REFID=11718
Also		ZPHY C37 179	E. Klemp et al.	(HEIDP, ANL, ILLG)	REFID=40404
CRESTI	86	PL B177 206	M. Cresti <i>et al.</i>	(PADO)	REFID=11720
Also		PL B200 587 (erratum)	M. Cresti <i>et al.</i>	(PADO)	REFID=40343
GREENE	86	PRC 56 819	G.L. Greene <i>et al.</i>	(NBS, ILLG)	REFID=11722
KOESTER	86	Physica B137 282	L. Koester <i>et al.</i>		REFID=48493
KOSVINTSEV	86	JETPL 44 571	Y.Y. Kosvintsev, V.I. Morozov, G.I. Terekhov	(KIAE)	REFID=40303
		Translated from ZETFP 44 444.			
TAKITA	86	PR D34 902	M. Takita <i>et al.</i>	(KEK, TOKY+)	REFID=11723
DOVER	85	PR C31 1423	C.B. Dover, A. Gal, J.M. Richard	(BNL)	REFID=41128
FIDECARO	85	PL 156B 122	G. Fidecaro <i>et al.</i>	(CERN, ILLG, PADO+)	REFID=11716
PARK	85B	NP B252 261	H.S. Park <i>et al.</i>	(IMB Collab.)	REFID=11717
BATTISTONI	84	PL 133B 454	G. Battistoni <i>et al.</i>	(NUSEX Collab.)	REFID=11714
JONES	84	PRL 52 720	T.W. Jones <i>et al.</i>	(IMB Collab.)	REFID=11715
PENDLEBURY	84	PL 136B 327	J.M. Pendlebury <i>et al.</i>	(SUSS, HARV, RAL+)	REFID=40278
CHERRY	83	PRC 50 1354	M.L. Cherry <i>et al.</i>	(PENN, BNL)	REFID=11709
DOVER	83	PR D27 1090	C.B. Dover, A. Gal, J.M. Richard	(BNL)	REFID=40097
KABIR	83	PRL 51 231	P.K. Kabir	(HARV)	REFID=41127
MOSTOVY	83	JETPL 37 196	Y.A. Mostovoy	(KIAE)	REFID=11710
		Translated from ZETFP 37 162.			
ROY	83	PR D28 1770	A. Roy <i>et al.</i>	(TATA)	REFID=11712
VAIDYA	83	PR D27 486	S.C. Vaidya <i>et al.</i>	(TATA)	REFID=11713
GAELHER	82	PR D25 2887	R. Gahler, J. Kalus, W. Mampe	(BAYR, ILLG)	REFID=11706
GREENE	82	Meteorologia 18 93	G.L. Greene <i>et al.</i>	(YALE, HARV, ILLG+)	REFID=11707
ALTAREV	81	PL 102B 13	I.S. Altarev <i>et al.</i>	(PNPI)	REFID=11702
BARABANOV	80	JETPL 32 359	I.R. Barabanov <i>et al.</i>	(PNPI)	REFID=11698
		Translated from ZETFP 32 384.			
BYRNE	80	PL 92B 274	J. Byrne <i>et al.</i>	(SUSS, RL)	REFID=11699
KOSVINTSEV	80	JETPL 31 236	Y.Y. Kosvintsev <i>et al.</i>	(JINR)	REFID=11701
		Translated from ZETFP 31 257.			
MOHAPATRA	80	PRC 44 1316	R.N. Mohapatra, R.E. Marshak	(CUNY, VPI)	REFID=41126
ALTAREV	79	JETPL 29 730	I.S. Altarev <i>et al.</i>	(PNPI)	REFID=11694
		Translated from ZETFP 29 794.			
EROZOLIM...	79	SJNP 30 356	B.G. Erozolimsky <i>et al.</i>	(KIAE)	REFID=11695
		Translated from YAF 30 692.			
NORMAN	79	PRL 43 1226	E.B. Norman, A.G. Seamster	(WASH)	REFID=11697
BONDAREN...	78	JETPL 28 303	L.N. Bondarenko <i>et al.</i>	(KIAE)	REFID=11691
Also		Translated from ZETFP 28 328.			
EROZOLIM...	78	Smolenic Conf.	P.G. Bondarenko	(KIAE)	REFID=11692
		SJNP 28 48	B.G. Erozolimsky <i>et al.</i>	(KIAE)	REFID=11689
		Translated from YAF 28 98.			
STRATOWA	78	PR D18 3970	C. Stratowa, R. Dobrozemsky, P. Weinzierl	(SEIB)	REFID=11690
EROZOLIM...	77	JETPL 23 663	B.G. Erozolimsky <i>et al.</i>	(KIAE)	REFID=11687
		Translated from ZETFP 23 720.			
KOESTER	76	PRL 36 1021	L. Koester <i>et al.</i>	(YALE, ISNG)	REFID=48494
STEINBERG	76	PR D13 2469	R.I. Steinberg <i>et al.</i>	(YALE, ISNG)	REFID=11683
DOBROZE...	75	PR D11 510	R. Dobrozemsky <i>et al.</i>	(SEIB)	REFID=11684
KROHN	75	PL 55B 175	V.E. Krohn, G.R. Ringo	(ANL)	REFID=11685
EROZOLIM...	74	JETPL 20 345	B.G. Erozolimsky <i>et al.</i>	(KIAE)	REFID=11681
		Translated from ZETFP 20 745.			
KROPF	74	ZPHY 267 129	H. Kropf, E. Paul	(LINZ)	REFID=11679
Also		NP A154 160	H. Paul	(VIEN)	REFID=11680
STEINBERG	74	PRL 33 41	R.I. Steinberg <i>et al.</i>	(YALE, ISNG)	REFID=11682
COHEN	73	JPCRD 2 664	E.R. Cohen, B.N. Taylor	(RISC, NBS)	REFID=10098
KROHN	73	PR D8 1305	V.E. Krohn, G.R. Ringo		REFID=48495
CHRISTENSEN	72	PR D5 1628	C.J. Christensen <i>et al.</i>	(RISO)	REFID=11676
CHRISTENSEN	70	PR C1 1693	C.J. Christensen, V.E. Krohn, G.R. Ringo	(ANL)	REFID=11672
EROZOLIM...	70C	PL 33B 351	B.G. Erozolimsky <i>et al.</i>	(KIAE)	REFID=41111
GRIGOREV	68	SJNP 6 239	V.K. Grigoriev <i>et al.</i>	(ITEP)	REFID=11668
		Translated from YAF 6 329.			
KROHN	66	PR 148 1303	V.E. Krohn, G.R. Ringo	(COLU, BNL)	REFID=48496
LEE	56	PR 104 254	T.D. Lee, C.N. Yang	(COLU, BNL)	REFID=52162